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PATENT
4450-0370P

IN THE U.S. PATENT AND TRADEMARK OFFICE

Applicant:	Balakrishnan SRIDHAR, et al.	Conf.:	3540
Appl. No.:	09/677,344	Group:	3663
Filed:	October 2, 2000	Examiner:	Cunningham
For:	THREE-STAGE OPTICAL AMPLIFIER HAVING FLAT SPECTRAL GAIN		

DECLARATION UNDER 37 C.F.R. § 1.131

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

July 30, 2003

Sir:

1. I, Balakrishnan Sridhar, hereby declare as follows:

2. I am an Inventor of the subject matter disclosed and claimed in the above-identified U.S. Patent application.

3. I understand that the patent Examiner has made several rejections of the claims all of which rely upon Taylor et al. (U.S. Patent 6,057,959). It is my understanding that the Taylor et al patent is effective as a reference against the above-identified U.S. Patent application under 35 U.S.C. § 102(a) as of May 2, 2000

(the publication date of Taylor et al.).

4. I am also very familiar and, indeed, and inventor of the Taylor et al. patent.

5. I conceived and reduced to practice the invention claimed in the above-identified patent application prior to the earliest publication date of the Taylor et al. patent, May 2, 2000. As evidence of prior invention, the following item is attached. Exhibit 1 is an excerpt of the CIENA Functional Specification for the CoreStream Wideband Amp/25-12. This Function Specification was prepared prior to May 2, 2000 as part of the normal and periodic documentation of inventions and was otherwise prepared in the normal course of business. The relevant portions showing the inventive concepts have been included in Exhibit 1 and non-relevant and trade secret information has been redacted.

6. I confirm that the CoreStream Wideband Amp/25-12 described in Exhibit 1 corresponds to and documents the actual reduction to practice of the invention disclosed and claimed in the above-identified U.S. Patent Application.

7. I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the

like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issuing therefrom.

Dated: 07-30-03

Signed: B. Sridhar

Balakrishnan Sridhar

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EXHIBIT

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Functional Specification

CoreStream
Wideband Amp/25-12

130-2205-000 Rev 1

REVISION SUMMARY

2.0 Functional Description

2.1 Overview

The Corestream Wideband Amp/25-12 (aka GFA II) module contains two gain flattened Erbium doped fiber amplifiers in double wide R3 form factor. The Corestream Wideband Amp/25-12 module operates in conjunction with 4 dual 980 nm/1480 nm pump modules (130-0258-900) to provide amplification. The GFAII has a usable bandwidth of
and provides a maximum gain of 25 dB while supporting up to 100 km of dispersion compensation (DCF). The new features provided with this release of the GFA II include:

- Supports 10G operation on NDSF, with an additional stage to overcome DCF loss
- Establish capability to have SAME span designs on NDSF as GFA I on NZDSF
- Supports up to 100 km of DCF without having to comprimise span design
- Adaptive gain control with embedded variable optical attenuator
- Support for 1625 nm service channel modules
- Fail-Soft operation with a single pump failure
- Temperature compensation for Erbium doped fiber
- Useable as an OADM node amplifier without any design modifications to this circuit pack.

Like the GFAI, the GFAII has instrumented sensor points at the input and output to measure the input and output powers of the amplifier. In addition the GFA II has the following monitor points; Pre-Amp output monitor, Post-amp input monitor, Atten In monitor, Atten Out monitor. This document describes the optical and electrical characteristics of the Corestream Wideband Amp/25-12 (GFA II).

2.2 System Perspective

The GFA provides improvements in performance over the previous GFA I amplifier, in that it provides for ability to integrate dispersion compensation into the amplifier without having to trade-off span design performance. This is the result of moving the GFA II design to an 3 stage amp, with dispersion compensation being supported out of the 1st stage of the amp (pre-amp). The factors that limit the performance of an amplified optical link include ASE noise accumlation in the amplifiers, tilt accumlation, dispersion and non-linear cross talk. The goal of the Corestream Wideband Amp/25-12 design is to provide a 'black box' replacement to the earlier version amplifiers which will support channels plans across the BW, AND not comprise span designs when dispersion compensation is utilzed (predominately 10G applications). The GFA II will support the same span designs (2.5 G) on NDSF as GFA I did on NZDSF, with the same or better system performance. The section below provides a description of the various aspects of the GFA design and performance.

2.3 Block Diagram Description

The figure below (FIG 1) shows the block diagram of the Gain Flattened Amplifier. The GFA is a three stage amplifier. The first stage & second stages are pumped with high power 980 nm pumps. The third stage is pumped by two high power 1480 nm pumps (co & counter propagating). The first & second gain stage is highly inverted and provides high gain and low noise figure. The output stage is a power amplifier, with the 1480 nm pumps providing high optical conversion efficiency. The gain flattening and service channel filters, variable optical attenuator are located in between the second and third gain stages so that the effect on noise figure and output power of the amplifier are minimal.

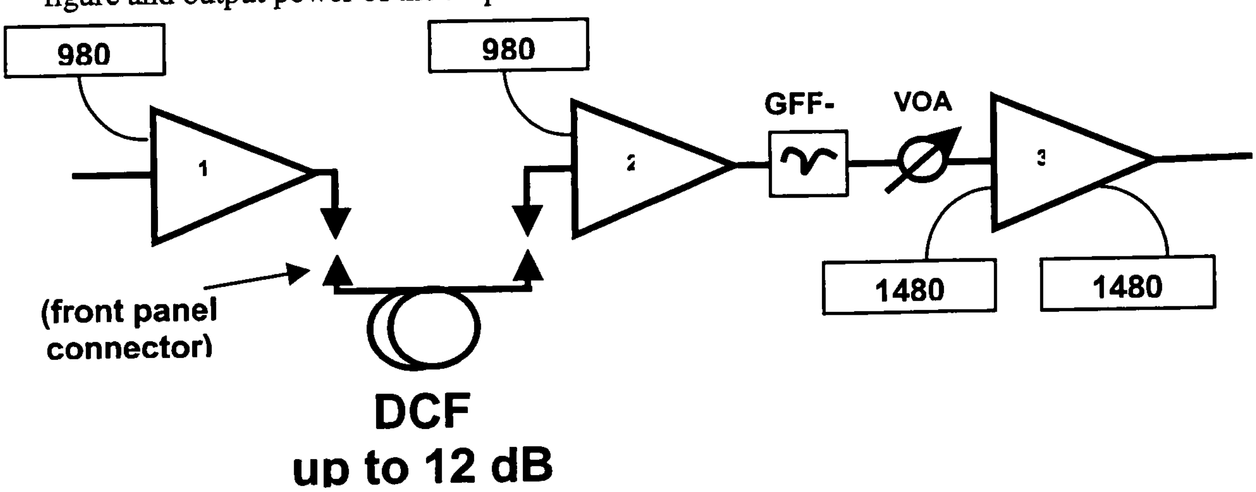

Figure 1. CoreStream Wideband Amp/25-12 (GFA II)

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2.3.1 Gain Flattening Filter

The gain flattening filter has a spectral attenuation shape, which compensates for the non-flatness of the Erbium amplifier gain shape. The gain shape of the Erbium amplifier depends on the whole range of parameters including the Erbium fiber composition, operating parameters such as pump power, wavelength etc and input power to the amplifier.

2.3.2 Service Channel Filter

The service channel provides a means of communication between remotely located network elements in a link. The amplifier merely provides a means to add and drop a signal at the the service channel signal and does not do any processing with it. The amplifier can support a service channel at 1625 nm.

2.3.3 Variable Optical Attenuator

The variable optical attenuator is embedded between the second & third stages of the amplifier. The variable attenuator is used to control the average inversion level of the amplifier so that the amplifier has a flat gain response irrespective of the input power into the amplifier. The amplifier is designed for a maximum span loss of 25 dB.

2.3.4 Pump Power requirements:

The Wideband Amp/25-12 uses modular external. The amplifier module requires 4 Dual 980/1480 pumps (130-0258-900) in order to achieve the maximum spand design guidelines.

Mid-stage diamond connectors:

Diamond connectors are provided mid-stage between the amplifiers. These connectors will enable hooking dispersion compensating fiber (DCF) fiber in the middle of the amplifier.

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2.5 Span Management Features

The span management software is a distributed control and management software that runs on the NCP of each network element. The span management software interacts with the various modules in the system including the amplifiers, pumps, transmitters and recievers. The features that affect amplifier performance are listed below.

- Safety shutdown in event of fiber break
- Maximum output power control (hard safety limit)
- Output power control as a function of channel count, fiber type etc.
- Adpative gain control

A detailed description can be found the span management document. The new feature that has been added to span management is adaptive gain control of amplifiers, which will enable the amplifier will operate with a flat gain response over a wide range of span losses and input powers. This is done by controlling an embedded variable optical attenuator within the amplifier.

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Further, since span management has a distributed and global view of the system, it is possible to correct residual tilt at the end node (obtained from receiver power levels) by adjusting the attenuation levels at the amplifiers upstream. This feature will not be implemented in the initial release of the system software. The following section decribes adaptive gain control in detail.

2.6 Adaptive Gain Control of Corestream Wideband Amp/25-12

A gain flattened amplifier without any active controls is designed to operate with a flat gain response for a fixed set of parameters, such as input signal power, pump powers etc. Any deviation from this set of parameters will cause the amplifier gain spectrum to tilt. Typically, in a system, the parameter that changes most often is the span loss between the amplifiers, and consequently the input power to the amplifiers. The figure below (figure 3) shows the tilt accumlation at the end of 5 spans (6 amplifier chains) for span losses ranging from 20 dB to 30 dB. The amplifier has been designed to operate with a flat gain spectrum at 25 dB span loss. The tilt roughly varies by about 1 dB for a 1 dB change in span loss for the current amplifier bandwidth. The corresponding variation for the MW4000 AMP/25 amplifer is only 0.2 dB for 1 dB change in span loss. The amplifier designed to operate with 96 channel bandwidth is sensitive to variations in input power and therefore an active compensation scheme will have to be used.

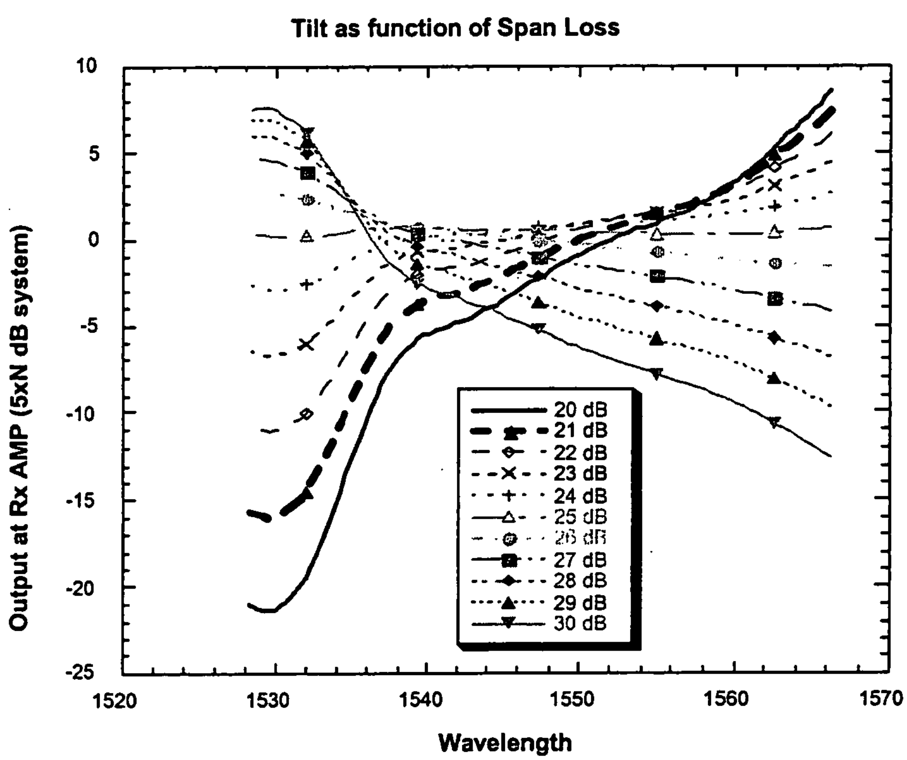

Figure 3. Amplifier Tilt without adaptive gain control

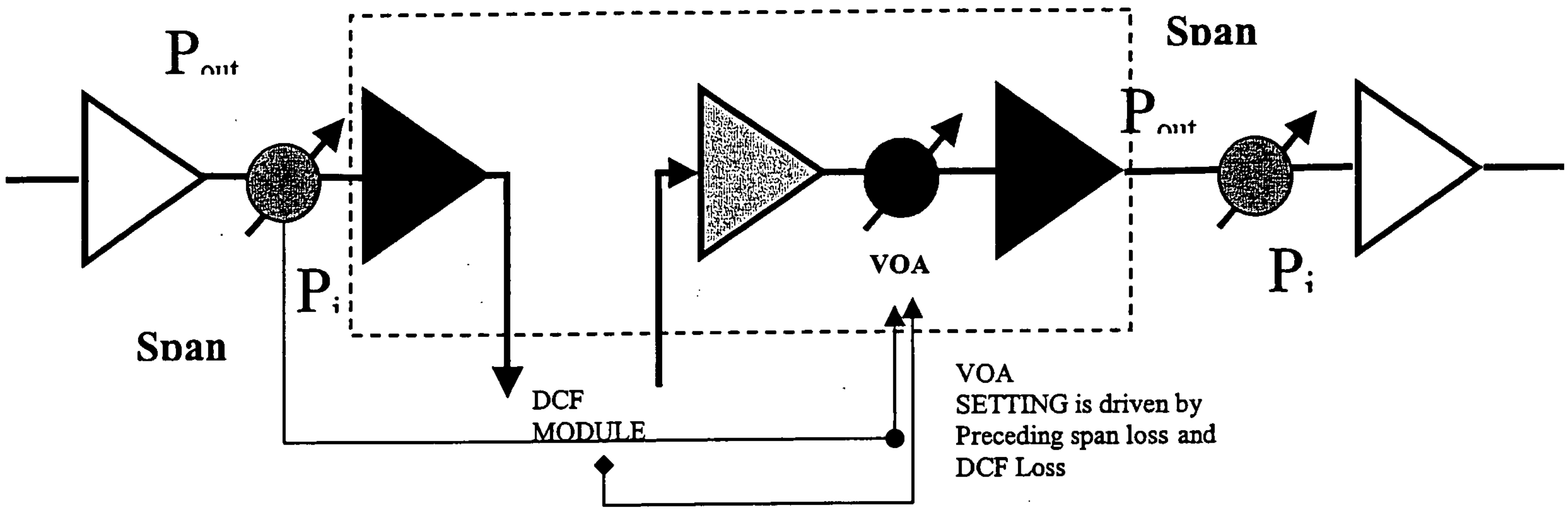

Figure 4: Adaptive control of Gain Flattened Amplifier

The compensation scheme used with the Corestream Wideband Amp/25-12 is illustrated in figure 4. A variable optical attenuator is embedded between the second and third stages of the amplifier. The amplifier operates with a flat gain response when the average population inversion of Erbium ions is at a particular level. This corresponds to an fixed input power level(for a particular set of pump power levels). When the span loss preceding the line amplifier is lower than the design loss, the input power to the amplifier is higher. This results in a lower average inversion level in the first stage of the amplifier. The variable attenuator is used to compensate for the drop in average inversion level of the first & second stage of the amplifier by increasing the average inversion level of the third stage of the amplifier. This is accomplished by decreasing the input to the third stage of the amplifier (by increasing the attenuation).

The method for implementation on the system is as follows: All amplifiers will have some residual non-flatness depending on a number of factors such as variation in the length of Erbium fiber, variation in gain flattening filters and other optical components. During the calibration process the amplifier is fed with a comb of input signals (or a white light source). The input power of the signals correspond to the rated input at 25 dB span loss. The attenuator is adjusted until the non-flatness of the output spectrum is at minimum. The attenuator offset level is stored internally and is defined as the attenuator offset.

During normal operation of the amplifier, the span loss of the fiber is below the maximum allowable span loss of the amplifier. The output of each amplifier is determined by the number of channels propagating through it and the fiber type (NDSF, LS, TW etc). The SPAN LOSS ERROR and DCF LOSS ERROR terms are both establish for a particular application.